Tricuspid & Pulmonary Valve Disease

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7th annual Houston Echo Review 2016: Boot Camp for the Echo Board
Houston, Texas
Which leaflet?
Which leaflet?
**PSLAX** ant & post leaflets

**PSSAX** ant & septal leaflets

4 chamber view
anterior & septal leaflets
Right-Sided Valve Lesions

**Tricuspid Valve**
- a. Normal anatomy
- b. TR
- c. TS

**Pulmonary Valve**
- a. Normal Anatomy
- b. PR
- c. PS
Tricuspid Valve
(Atrioventricular Valve)

- Leaflets
- Annulus
- Chordae Tendinae
- Papillary Muscles
- Right Ventricle
- Atrium
TV Anatomy

“Moss & Adams” 1995
TV 4 chamber View

FIGURE 14-1. Apical four-chamber echocardiographic view in a patient
TV: Multiple views

PSLAX / RVIT

A
P

4ch

A
S

A
S

Subcostal 4ch
TR Velocity: CW Doppler (SPAP) Multiple Angles

- Estimation of Systolic PAP
- Modified Bernoulli $P = 4V^2$
- SPAP = RVSP + est. RAP
Right-Sided Valve Lesions

**Tricuspid Valve**

a. Normal anatomy

b. TR

c. TS

**Pulmonary Valve**

a. Normal Anatomy

b. PR

c. PS
Abnormal Tricuspid Regurgitation

- **ACQUIRED (native valve)**
  - **Functional**
    - Chronic Volume overload:
      - ASD, PR, chronic TR begets TR
    - RV failure (acute)
      - Pulm Embolus
      - RV infarction
    - RV failure (chronic)
      - Primary pulmonary hypertension
      - Secondary (left-sided lesions)
  - **Organic Valve disease**
    - Rheumatic
    - Endocarditis
    - Myomatous degeneration / prolapse
    - Endomyocardial Biopsy (trauma)
    - Trauma (deceleration injury—anterior leaflet tear—remote)
    - Inflammatory / fibrosis
      - Carcinoid heart disease
      - Endomyocardial fibroelastosis
      - Methylsergide (ergotamine)
      - SLE
      - Radiation valvulitis
    - Tumors (wrecking ball / distortion)
- **CONGENITAL**
  - Ebstein’s Anomaly
  - Non-Ebstein’s congenital (AV canal, VS aneurysm, TGA, RV pressure / vol. Overload)
- **PROSTHETIC VALVE**
Severe TR

M-mode
- Paradoxical Septal motion
- Chordal abnormality
- Leaflet abnormality
- Annular dilatation

Leaflet malcoaptation

2D
- RV dilatation
- RA dilatation
- Elevated RA pressure
- Hepatic Vein systolic wave
- CW Doppler dense, inflow $V \geq 1 \text{ m/s}$
- CW Doppler v-wave cut off
- Color Doppler jet size
- ERO by PISA*
  - Large Proximal flow convergence zone
  - Large vena contracta

Doppler
Paradoxical Septum

**FIGURE 14-6.** Paradoxical septal motion indicates severe right ventricular volume overload, due in this case to isolated severe TR. A, Diastole—the interventricular septum flattens toward the LV cavity. B, Systole—paradoxical bulging of the interventricular septum away from the LV cavity.

Stainback RF. *HeartDz in Women*, Willerson & Wilanski, eds

Sev.TR  ASD  PI
M-Mode LV PSLAX

Paradoxical Septal Motion
Marked Volume Overload

**Paradoxical Septal Motion:** septum & inferolateral walls abnormally “track” each other on M-mode (PSLAX)
TR Velocity: CW Doppler
(severity by density & contour; & SPAP)

\[ P = 4V^2 \]

FIGURE 14-2. Four examples of tricuspid regurgitation (TR) velocity measurement and systolic pulmonary artery pressure (PAP) estimation by continuous-wave Doppler echocardiography (PAP = 4V^2 + P Ea, see text). A, Mild “physiologic” TR and normal PAP. Peak TR velocity (arrow) = 2.5 m/s; estimated RA pressure = 5 mm Hg, systolic PAP = 30 mm Hg. B, Moderate functional TR (chronic obstructive lung disease). Peak TR velocity (arrow) = 4 m/s; estimated RA pressure = 15 mm Hg, systolic PAP = 79 mm Hg. C, Moderate functional TR (advanced primary pulmonary hypertension). Peak TR velocity (arrow) = 5.7 m/s; estimated RA pressure = 20 mm Hg, systolic PAP = 150 mm Hg. D, Severe “low-pressure” TR (torn tricuspid leaflet). “V-wave cutoff” (triple arrows) and a dense regurgitation velocity signal indicate a large regurgitation volume.
Inferior Vena Cava

**FIGURE 14-7.** A, Subcostal echocardiographic view: severe right-sided heart failure is indicated by an engorged inferior vena cava (IVC) and hepatic vein (*), ascites (a) surrounding the liver (L), and a dilated right atrium (RA). B, In the same patient, pulsed Doppler blood-flow velocity measurement in the hepatic vein demonstrates two significant flow reversals: diastolic “A wave” (A) indicating high RV end-diastolic pressure and a large systolic “S wave” (S) indicating severe tricuspid regurgitation. (Arrow, early diastolic forward flow [prominent y descent of severe TR].)

Stainback RF. HeartDz in Women. Willerson & Wilanski, eds
Severe TR

V-wave cut off
Severe TR: Large Hepatic Vein Systolic Wave

Normal

Patient A

Patient B

Patient C
Functional TR (multifactorial) LV diastolic dysfunction, CAD, MR, RV volume or pressure overload
Acquired TV Disease
Carcinoid Heart Disease

**FIGURE 14-4.** Carcinoid heart disease with RV and RA dilatation due to severe tricuspid regurgitation. The tricuspid valve leaflets (*double arrows*) are thickened and frozen in the open position during ventricular systole, while the mitral valve (*single arrow*) closes appropriately.

Echo:TV.PV.dz  
Stainback RF. *HeartDz in Women*, Willerson & Wilanski, eds
Congenital TV Disease
FIGURE 14-5. A 45-year-old patient with Ebstein’s anomaly. A, Apical four-chamber echocardiographic view shows a hugely dilated RA due to severe TR and an “atrialized” RV component (triple arrows), along with marked apical displacement of the tricuspid valve’s septal-leaflet attachment (double arrows) relative to the mitral valve’s anterior leaflet (single arrow). B, Parasternal short-axis view: massive RA and RV dilatation and a small, underfilled LV in cross-section. The anterior tricuspid valve’s leaflet (single arrow) is markedly elongated and “sail-like.”

Stainback RF. HeartDz in Women. Willerson & Wilanski, eds
Echo:TV.PV.dz
Ebstein’s Anomaly
Case 1 after “laser lead extraction” for pacemaker endocarditis (patient now asymptomatic)
Case 1 after “laser lead extraction” for pacemaker endocarditis (patient now asymptomatic)
Case 1 after “laser lead extraction” for pacemaker endocarditis (patient now asymptomatic)
Case 1 after “laser lead extraction” for pacemaker endocarditis (patient now asymptomatic)

Severe TR
Hepatic Vein Systolic wave
Case 2 cardiac transplant patient after multiple RV biopsies
Case 2 cardiac transplant patient after multiple RV biopsies

Torrential TR, low velocity: Color flow Doppler may be misleading

CW Doppler, TV

PW hepatic Vein
Case 4 22 yr female, DOE, syncope (PPH)

Non-imaging CW & multiple window interrogation

4 m/sec

5 m/sec
Note: Severe Chronic Pulm HTN

• TR may be mild, despite dilated RV
• flattened / D-shaped septum (versus paradoxical septum) (although the two may co-exist)
Right-Sided Valve Lesions

Tricuspid Valve
a. Normal anatomy
b. TR
c. TS

Pulmonary Valve
a. Normal Anatomy
b. PR
c. PS
Tricuspid Stenosis

• Rheumatic TS (TS/TR)
• Non-rheumatic TS
  – Prosthetic
    • thrombosis
    • Calcific deneration (tissue)
  – Tumor
  – Carcinoid (predominately TR)
• Post TV annuloplasty (iatrogenic)
Clinically significant TS

TV inflow gradient > 5 mm Hg (mean)
At normal resting HR & SV
CW Doppler, TV

TV inflow mean Grad. = 8 mm Hg
Mixed TS / TR

Carcinoid Heart Disease
TV mechanical Prosthesis

FIGURE 14-8. Tricuspid stenosis due to thrombosis of a bileaflet mechanical prosthesis before (A) and 36 hours after (B) continuous intravenous urokinase therapy. In A, the peak tricuspid inflow velocity (arrow) equals 1.8 m/s (13 mm Hg), with normalization of the inflow velocity to 1 m/s in B.

Stainback RF. HeartDz in Women, Willerson & Wilanski, eds

Thrombolysis
Right-Sided Valve Lesions

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Pulmonary Valve
a. Normal Anatomy
b. PR
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Right-Sided Valve Lesions

**Tricuspid Valve**
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**Pulmonary Valve**
- a. Normal Anatomy
- b. PR
- c. PS
Pulmonary Valve Disease

- Pulmonary Insufficiency
  - Acquired
    - Endocarditis: IVDA, indwelling catheters
    - Carcinoid
    - Pulmonary HTN
    - Prosthesis (homograft)
  - Congenital
    - Post TOF repair

- Pulmonary Stenosis
  - Acquired
    - Carcinoid
    - Rheumatic (RARE)
    - Prosthesis (homograft)
  - Congenital
    - Isolated PS (balloon)
    - TOF: RVOT, Valve
    - Complex Congenital
**Pulmonary Valve**
(arterial / semilunar)

- Three Cusps
- Similar size, tensile strength, AoV
- Muscular infundibulum (RVOT)
TTE PV: well aligned for Doppler, PSLAX

PSSAX

PW Doppler

CW Doppler
TEE: Bioprosthetic PV dysfunction

Severe PS & Severe PR
unconventional TEE views

Transgastric (TEE)

Sev PR

Ao Arch (TEE)

Sev PS 4 m/s
Congenital PS with atrioventricular septal defect (AV canal)

Estimate Systolic PA pressure
Congenital PS with atrioventricular septal defect (AV canal)

Peak RVSP = 81 mm Hg + RAP (15 mm Hg) = 96 mm Hg

Peak PV pressure gradient = 64 mm Hg

Peak SPAP = 96 mm Hg − 64 mm Hg = 32 mm Hg
Case: 24 yr male, infant
TOF repair, No symptoms

Aneurysmal RVOT

Severe “free” PR, mild PS

Sev. RV dilatation; Trace TR

VSD Patch
Carcinoid Heart Disease: PS & PR

**FIGURE 14-9.** Continuous-wave Doppler pulmonary valve signal in a patient with carcinoid heart disease and severe pulmonary valve insufficiency (PI, reverse diastolic flow above the baseline) and mild pulmonary stenosis (PS, forward systolic flow below the baseline). The forward velocity equals 2.5 m/s (25 mm Hg peak transvalvular gradient).

Stainback RF. *HeartDz in Women,* Willerson & Wilanski, eds
Cases
Case A:
Case A:

Degree of PS / PR??
Mechanism??
Case A:
Case A:

Carcinoid Heart Disease (TV & PV)

TR > TS  PR > PS (left valves spared)
Case B

Echo:TV.PV.dz
Case B:
Case B:

Ebstein’s Anomaly
Case C: Intraoperative TEE
Case C:
Case C:

TTE: follow up TV annuloplasty
Case D:

CW Doppler, Pulmonary Valve / RVOT
Case D:
Case D:

PDA (small, restrictive)
Case E: h/o balloon valvuloplasty of PV

PV Peak = 33 mm Hg
Case E:

Reassess Pulmonary Trunk: post-stenotic dilatation
(ASD also could dilate Pulm Trunk)
Case F:

Differential Diagnosis of TV dz?
Case F:
Case G:

Likely associated TV and / or PV disease?

Echo:TV.PV.dz
Case G:

TEE: Tetralogy of Fallot repair, r/o VSD Patch leak

(no patch leak; AR jet)
Teaching Points

- TV & PV dz co-exist
- TS is rare (don’t miss)
  - rheumatic, post TV repair, prosthetic
- TS, small gradient = big sx’s
- Visible TV leaflet malcoapt = severe TR (be skeptical of Color Doppler)
- Moderate TR color Doppler = lg color jet (don’t overcall)
- Unobstructed / torrential TR or PR: Color Doppler “jet” (don’t miss)
- Recognize 2D signs of RV volume overload
  - Paradoxical septal motion, Lg RV, RA, IVC
- Functional TR severity may be dynamic (change with volume status)

- Mild TR and Mild PR are prevalent in the normal adult population
- PR Doppler jets & M-mode useful as indirect hemodynamic signs of PAP (covered separately)
- Severe TR and PR are clinically well tolerated unless there is “downstream” pathology (elderly)
- Peak SPAP by Doppler with PS: must subtract peakPV gradient from Peak RVSP gradient!
- Unobstructed TR—unable to estimate RV systolic pressure.